IN THE SPECIFICATION

Please replace the paragraph beginning at page 1, line 5, (Pub. No.: US 2002/0148984 A1 paragraph number 0002) with the following rewritten paragraph:

The present invention relates to a system~~,~~ and process ~~for use thereof,~~ for inspecting wafers and other semiconductor or microelectronic substrates, and specifically for inspecting three dimensional (3D) surfaces or features thereon ~~such as bumps~~. Specifically, the present invention relates to a confocal optical system for inspecting ~~bumps and other~~ 3D features such as bumps on wafers or like substrates, and a process of using such system.

Please replace the paragraph beginning at page 1, line 13, (Pub. No.: US 2002/0148984 A1 paragraph number 0004) with the following rewritten paragraph:

Over the past several decades, the microelectronics and semiconductor industry has exponentially grown ~~in use and popularity~~. Microelectronics and semiconductors have, in effect, revolutionized society by ~~introducing computers, electronic advances, and generally revolutionizing~~translating many previously difficult, expensive and/or time consuming mechanical processes into simplistic and quick electronic processes. This booming industry has been fueled ~~by~~ with an insatiable desire ~~by~~ from businesses and individuals for computers and electronics, and more particularly, faster, more advanced computers and electronics whether it be on an assembly line, on test equipment in a lab, on the personal computer at one's desk, or in the home via electronics and toys.

Please replace the paragraph beginning at page 1, line 28, (Pub. No.: US 2002/0148984 A1 paragraph number 0006) with the following rewritten paragraph:

One evolving process associated with the microelectronics industry ~~that has evolved over the past decade plus~~ is the microelectronic and semiconductor inspection process. The merit in inspecting microelectronics and semiconductors throughout the manufacturing process is obvious in that bad wafers may be removed at the various steps rather than processed to completion only to find out a defect exists either by end inspection or by failure during use. In

the beginning, wafers and like substrates were manually inspected such as by humans using microscopes. As the process has evolved, many different systems, devices, apparatus, and methods have been developed to automate this process such as the method developed by August Technology and disclosed in U.S. Patent Application No. 09/352,564. Many of these automated inspection systems, devices, apparatus, and methods focus on two dimensional inspection, that is inspection of wafers or substrates that are substantially or mostly planar in nature.

Please replace the paragraph beginning at page 2, line 5, (Pub. No.: US 2002/0148984 A1 paragraph number 0007) with the following rewritten paragraph:

One rapidly growing area in the semiconductor industry is the use of bumps or other three dimensional (3D) features that protrude outward from the wafer or substrate. The manufacturers, processors, and users of such wafers or like substrates having bumps or other three dimensional features or projections desire to inspect these wafers or like substrates in the same or similar manner as the inspection of the two dimensional substrates. However, many obstacles exist as the significant height of bumps or ~~the like causes~~other features cause focusing problems, shadowing problems, and just general depth perception problems. Many of the current systems, devices, ~~apparatus~~apparatuses, and methods are either completely insufficient to handle these problems or cannot satisfy the speed, accuracy, and other requirements.

Please replace the paragraph beginning at page 2, line 18, (Pub. No.: US 2002/0148984 A1 paragraph number 0008) with the following rewritten paragraph:

The present invention addresses ~~The~~ inspecting ~~of~~ semiconductors or like substrates, and specifically the inspection of three dimensional surfaces or features, such as bumps. ~~, is accomplished by the present invention, which is~~In particular, the present invention includes a confocal sensor with a given depth response ~~functioning~~ using the principle of eliminating out of focus light ~~thereby resulting in the sensor producing~~ to produce a signal only when the surface being inspected is in a narrow focal range. The result is an accurate height determination for a given point or area being inspected such that the cumulation of a plurality of height determinations from use of the confocal sensor system across a large surface allows the user to

determine the topography thereof.

Please replace the paragraph beginning at page 2, line 35, (Pub. No.: US 2002/0148984 A1 paragraph number 0010) with the following rewritten paragraph:

Preferred embodiments of the invention, illustrative of the best mode in which applicant has contemplated applying the principles, are set forth in the following description and are shown in the drawings and are particularly and distinctly pointed out and set forth in the appended claims.

Please replace the paragraph beginning at page 3, line 16, (Pub. No.: US 2002/0148984 A1 paragraph number 0013) with the following rewritten paragraph:

The three dimensional (3D) inspection system of the present invention, ~~is~~ indicated generally ~~at~~ as 120, ~~as~~ is best shown overall in ~~Figure~~ FIG. 1 and is used in one environment to view, inspect, or otherwise optically measure three dimensional features or projections on surfaces. One example is the measurement of bumps on wafers or like substrates. The 3D inspection system includes a light source 122, an optical subsystem 124, and a camera 126. The optical subsystem includes a beamsplitter 130, an aperture array 132, an object reimager 134, and a camera reimager 136.

Please replace the paragraph beginning at page 3, line 14, (Pub. No.: US 2002/0148984 A1 paragraph number 0014) with the following rewritten paragraph:

The light source 122 is any source of light that provides sufficient light to illuminate the sample S. ~~, and the~~ The light source may be positioned in any position so long as it provides the necessary light to sample S to be viewed, inspected or otherwise optically observed. Examples of the light source include, but are not limited to, white light sources (such as halogen or arc lights), lasers, light emitting diodes or LEDs ~~(LEDs)~~ (including white LEDs or any of the various colored LEDs), fluorescent lights, or any other type of light source.

Please replace the paragraph beginning at page 4, line 4, (Pub. No.: US 2002/0148984 A1 paragraph number 0017) with the following rewritten paragraph:

This light source provides sufficient energy to illuminate the sample S and is typically filtered. The light emitted from the light source 122 is directed into the optical subsystem 122. Specifically, the light is directed toward beamsplitter 130.

Please replace the paragraph beginning at page 4, line 7, (Pub. No.: US 2002/0148984 A1 paragraph number 0018) with the following rewritten paragraph:

In more detail, and in the embodiment shown in ~~the Figures~~FIG. 1, the optical subsystem 124 includes beamsplitter 130, aperture array 132, object reimager 134, and camera reimager 136.

Please replace the paragraph beginning at page 4, line 10, (Pub. No.: US 2002/0148984 A1 paragraph number 0019) with the following rewritten paragraph:

Beamsplitter 130 in the embodiment shown is a pellicle beamsplitter. A pellicle beamsplitter ~~has several advantages since~~is preferable as it is achromatic, has very low polarization effects, and less variation with angle and color issues, and more uniformly provides light even after beam splitting effects ~~than~~ in comparison to a polarized beamsplitter.

Please replace the paragraph beginning at page 4, line 15, (Pub. No.: US 2002/0148984 A1 paragraph number 0020) with the following rewritten paragraph:

Another important feature is the design, setup, alignment and configuration of the light source 122, pellicle beam splitter 130 and the aperture array 132 as is shown in the ~~Figure~~ FIG. 1. The light or illumination source 122 provides reflected light to the beamsplitter whereby some of this light is lost as it passes through the beamsplitter and eminates out of the entire system ~~and is lost~~, a small amount of the light ~~may~~ is possibly be lost within the beamsplitter, and the remaining light is reflected toward the aperture array.

Please replace the paragraph beginning at page 4, line 22, (Pub. No.: US 2002/0148984 A1 paragraph number 0021) with the following rewritten paragraph:

The beamsplitter 130 is a pellicle beamsplitter and is of a broadband configuration. In contrast to a polarizing beamsplitter, where incoming light is reflected at 90 degrees to the path of at least one of the paths of outgoing light such that incoming and all exiting light are basically near normal incident to the faces of the cube, the pellicle beamsplitter in this embodiment overcomes ~~the detrimental~~ design limitations of a typical cube beamsplitter of any type including either an achromatic or chromatic type. This broadband configuration is necessary because in a typical achromatic beamsplitter it is difficult to successfully achieve very small fresnel reflections on the surfaces unless the beamsplitter includes coatings that adopt broad wavelength ranges which are very expensive, very sophisticated and difficult to provide.

Please delete the paragraph beginning at page 4, line 33, (Pub. No.: US 2002/0148984 A1 paragraph number 0022) as follows:

~~Aperture array 132 in the embodiment shown is an opaque pinhole array.~~

Please replace the paragraph beginning at page 4, line 34, (Pub. No.: US 2002/0148984 A1 paragraph number 0023) with the following rewritten paragraph:

Preferably, the aperture array 132 in the embodiment shown is an opaque pinhole array. The pinhole array in the most preferred embodiment is an approximately 100 pinhole by an approximately 1000 pinhole array, where the holes in this embodiment are of a circular nature. ~~although other configurations are contemplated.~~ However, other pinhole configurations, apertures, ~~pinhole~~ arrays or like arrays of differing numbers and ranges of holes are contemplated.

Please replace the paragraph beginning at page 5, line 15, (Pub. No.: US 2002/0148984 A1 paragraph number 0026) with the following rewritten paragraph:

However, in another embodiment, oversampling is used, meaning the system has more pinholes than camera pixels, and as such, more than one pinhole is mapped or correlated into

each pixel. In yet another embodiment that is preferred, undersampling is used, meaning the system has more camera pixels than pinholes, and as such, less than one pinhole is mapped or correlated into each pixel. This undersampling reduces the effects of aliasing in the system so that holes do not have to match up directly with the pixels. ~~and t~~Thus, alignment, distortions, and imperfections in optical system and other similar issues are avoided ~~because~~ as this design assures that the same or substantially the same amount of light reaches each pixel regardless of the orientation, phase, etc. of the pixel with respect to a pinhole. The undersampling also broadens the depth response profile of our optical system to allow the system to operate over a broad range of three dimensional heights on the sample S.

Please replace the paragraph beginning at page 5, line 28, (Pub. No.: US 2002/0148984 A1 paragraph number 0027) with the following rewritten paragraph:

In addition, in one embodiment, the apertures are orthogonal or grid-like. However, in alternative embodiments the apertures are non-orthogonal or non-grid-like such as a hexagonal or other geometric pattern. This non-orthogonal pattern, in at least certain applications, reduces aliasing and alignment issues.

Please replace the paragraph beginning at page 5, line 2, (Pub. No.: US 2002/0148984 A1 paragraph number 0029) with the following rewritten paragraph:

Another ~~key~~ feature of this invention is that light passing from the aperture array is in transmission so that any surface anomalies on the pellicle beamsplitter are irrelevant to the imaging properties of ~~our~~ the system and ~~we are~~it is not susceptible to vibrations of the pellicle beamsplitter.

Please replace the paragraph beginning at page 6, line 6, (Pub. No.: US 2002/0148984 A1 paragraph number 0030) with the following rewritten paragraph:

The positioning of the aperture array ~~into~~in the system provides a confocal response. Only light that passes through an aperture in the aperture array, passes through the dual

telecentric object reimager, reflects off of the sample S, passes back through the dual telecentric object imager, and passes back through an aperture in the aperture array is in focus. This confocal principle results in bright illumination of a feature in focus ~~while~~and dim or no illumination of an out of focus feature.

Please replace the paragraph beginning at page 6, line 13, (Pub. No.: US 2002/0148984 A1 paragraph number 0031) with the following rewritten paragraph:

The object reimager 134 in the preferred embodiment shown is of a dual telecentric design. The object reimager includes a plurality of lenses separated by a stop. In one embodiment, the object reimager includes two to six lenses, and preferably three to four, on the right side of the reimager and two to six lenses, and preferably three to four, on the left side of the reimager, the two sides separated in the middle by the stop. Since the reimager is dual telecentric, the stop is located one group focal length away from the cumulative location of the lenses on each side.

Please replace the paragraph beginning at page 6, line 24, (Pub. No.: US 2002/0148984 A1 paragraph number 0033) with the following rewritten paragraph:

This system is unique in one aspect because it is a dual telecentric optical reimager. This preferred dual telecentric property means that when viewed from both ends, the pupil is at inifinity and ~~that~~ the chief rays across the entire field of view are all parallel to the optical axis. This provides at least two major benefits. One benefit ~~which~~ relates to the object or sample end of the reimager. At that end~~is that~~ magnification across the field remains constant as the objectives focus in and out in relation to the sample. ~~The~~ A second benefit relates to the aperture end of the reimager. At that end ~~where~~ the light that comes through the aperture array is collected efficiently as the telecentric object reimager aligns with the telecentric camera reimager.

Please replace the paragraph beginning at page 6, line 33, (Pub. No.: US 2002/0148984 A1 paragraph number 0034) with the following rewritten paragraph:

In other words, ~~The~~ a very high optical throughput may be achieved with the embodiments described herein~~is very high~~.

Please replace the paragraph beginning at page 6, line 34, (Pub. No.: US 2002/0148984 A1 paragraph number 0035) with the following rewritten paragraph:

In ~~an alternative~~a related embodiment, the numerical aperture of the object reimager may be adjustable or changeable by placing a mechanized iris in for the stop. This would allow for different depth response profile widths. This allows for broader ranges of bump or three dimensional measurements since the taller the object that it is desirable to measure the lower the desirable numerical aperture to maintain speed of the system. Similarly, the smaller the object to be measured, the more desirable it is to have a higher numerical aperture to maintain sharpness, i.e., accuracy.

Please replace the paragraph beginning at page 7, line 14, (Pub. No.: US 2002/0148984 A1 paragraph number 0037) with the following rewritten paragraph:

Generally speaking ~~T~~the camera reimager functions to provide a path for the light passing through the aperture array from the object reimager to the camera.

Please replace the paragraph beginning at page 7, line 16, (Pub. No.: US 2002/0148984 A1 paragraph number 0038) with the following rewritten paragraph:

The telecentric properties of the camera reimager are on the aperture array side or end so that it ~~efficiently and uniformly across the field of view~~ couples the light coming through the aperture array from the object reimager 134 efficiently and uniformly across the field of view. It is pixel sampling resolution limited so its aberrations are less than that from the degradation of the pixel sampling. Its numerical aperture is designed based upon the object reimager so any misalignments between the reimagers do not translate into a field dependent change in efficiency across the field of view.

Please replace the paragraph beginning at page 7, line 25, (Pub. No.: US 2002/0148984

A1 paragraph number 0040) with the following rewritten paragraph:

In addition, an optional feature in this invention that is used in certain embodiments is the canting of ~~either~~ the sample S with reference to the optical axis of the entire optical subsystem~~,~~. Alternatively, ~~or vice versa (that is the canting of~~ the entire optical subsystem can be canted with respect to the sample S~~)~~. ~~This~~ Either option compensates for the canting of the aperture array as described above, thus maintaining the Scheimpflug condition. In ~~the Figure~~FIG. 1, the canting is shown as α.

Please replace the paragraph beginning at page 8, line 2, (Pub. No.: US 2002/0148984 A1 paragraph number 0043) with the following rewritten paragraph:

In the embodiment shown in ~~the Figures~~FIG. 1, the camera 126 is a TDI camera. TDI provides additional speed by transferring the charge such that the system integrates light over time. ~~The aperture array with~~An alternative embodiment including a single line scan camera uses only one ~~array of pinholes~~line of apertures while with the TDI camera embodiment the aperture array is 100 or more ~~arrays~~lines by multiple apertures in each line (an example is 100 lines by 1024 apertures per line).

Please replace the paragraph beginning at page 8, line 12, (Pub. No.: US 2002/0148984 A1 paragraph number 0045) with the following rewritten paragraph:

Light passes through the system as follows: Light source 122 illuminates and directs such light toward beamsplitter 130. Some of the light that reaches the beamsplitter passes through the beamsplitter and ~~eminates~~ emanates out of the entire system thus avoiding interference with the system~~,~~. ~~a~~ A small amount of light is lost within the beamsplitter~~,~~. ~~and the~~The remaining light is reflected toward the aperture array. Light that reaches the aperture array either passes through an aperture therein, or hits the plate around the holes in the aperture array and is reflected out of the system due to the cant. Light that passed through the aperture array is reimaged and collimated in the dual telecentric object reimager. The light is directed toward the sample S and reflects off of the sample S. If the point that is illuminated is either in, or near focus, substantially all of the light reflects back into the object reimager. ~~while if~~If the

point is not in focus then little or ~~none~~no light is reflected back. Light passes back through the object reimager and is directed toward the aperture array. Light that reaches the aperture array either passes through an aperture therein, or hits the plate around the holes in the aperture array and is reflected out of the system due to the cant. Light that passed through the aperture array is in focus due to the confocal principle, and it is reimaged and collimated in the telecentric camera reimager. It is directed into the camera and the intensity recorded. In any given pass, the above process occurs for every point on the sample that is being viewed.

Please replace the paragraph beginning at page 9, line 1, (Pub. No.: US 2002/0148984 A1 paragraph number 0047) with the following rewritten paragraph:

In one ~~of the current design and~~ embodiment including measuring ~~for~~ bumps or other three dimensional features, ~~the~~ a measuring process involves two or more (generally three or more) passes over the sample surface S each at a different surface target elevation to measure surface elevation, followed by two or more (generally three or more) passes each at a different bump target elevations to measure bump elevation followed by calculations to determine bump height. ~~The result of the passes is an~~In this manner, at least two intensity measurements are taken for each point, each measurement at ~~each~~a different elevation. ~~where these points as to surface~~ The surface elevation measurements for each point are plotted or fitted to a Guassian or other curve. ~~and separately as to~~ The bump elevation measurements for each point are also plotted or fitted to a Gaussian or other curve. Thus, ~~to determine~~ the elevations of both the surface and the bump may be determined for each point measured. From these two elevations, ~~from which~~ the actual bump height at a given point ~~is~~ can then be determined. ~~It~~In other words, the actual bump height is the difference between the surface elevation and the bump elevation.

Please replace the paragraph beginning at page 9, line 29, (Pub. No.: US 2002/0148984 A1 paragraph number 0049) with the following rewritten paragraph:

The second step is to determine the elevation of these significant protrusions or valleys (such as bumps). Another pass is made over a portion or the entire surface of the sample S (often only where bumps are expected, known, or no intensity was found in the surface elevation

passes). This pass occurs at a course or rough approximation as to the elevation of the expected bumps such as 50, 100, 200, 300 or the like microns above the surface. Intensity is determined at each pixel as the entire sample (or only select locations where bumps are expected, known or no intensity was previously found) is scanned and the intensities are noted for each pixel, while if very small or no intensity at a given point then the system is significantly out of focus at that location or pixel (an example is scanning at bump elevations where no bump exists results in little or no intensity feedback). This step is generally repeated several more times (though any number of passes may be used so long as a curve can be calculated from the number of passes) at a slightly different elevation such as 5, 10 or 20 microns ~~different~~increments. The result is multiple data points of intensity for each pixel to plot or fit a Gaussian or other curve to determine the bump elevation at that point.

Please replace the paragraph beginning at page 11, line 27, (Pub. No.: US 2002/0148984 A1 paragraph number 0057) with the following rewritten paragraph:
In even yet another embodiment, single pass height determination is performed. Specifically, only one pass or scan occurs and gray scale variation is used to determine the height of each bump. As a result, only ~~ojne~~ one scan is used at one z axis elevation, followed by interpolation on a gray scale.